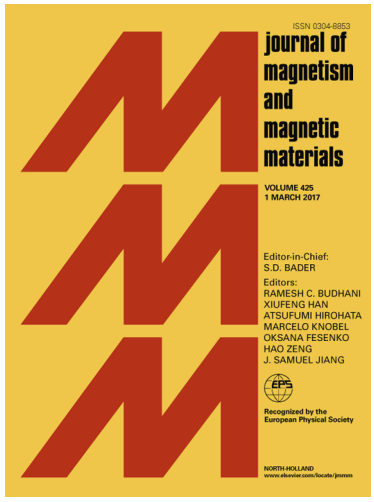

Research articles

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Annealing effects on the microstructure, magnetism and microwave-absorption properties of Fe/TiO_2 nanocomposites

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Abstract: To overcome the problems of Fe nanowires and obtain an outstanding material for the applications of magnetic recording and microwave absorption. Fe/TiO_2 core/shell nanowire arrays were fabricated by a controllable two-step electrodeposition technique using anodic aluminum oxide (AAO) membrane as template. The influences of annealing on the microstructure, magnetism and microwave-absorption properties of the arrays were studied. It was demonstrated experimentally that the partial crystallization of amorphous TiO_2 and the polycrystalline structure of TiO_2 originating from annealing enhanced the microwave-absorption properties of Fe/TiO_2 core/shell nanowire arrays. We also found that the nanowire arrays with small diameter exhibited more obvious magnetic anisotropy. Our study shows that Fe/TiO_2 core/shell nanowire arrays can be used towards magnetic recording and microwave absorption.

Key words: Fe/TiO_2 core/shell nanowire array; Template-based preparation; Annealing; Magnetic property; Microwave-absorption property

1. Introduction

Magnetic metallic nanowires can be used for the application of microwave absorption due to uniform size, well-defined shape, high specific surface area, high aspect ratio, and high magnetic anisotropy. Nevertheless, using pure magnetic metallic nanowires has practical limitations, including the formation of conductive network due to the agglomeration tendency, the growth of nanograins in the process of sintering, and the oxidization problem in air.

To effectively overcome these problems, coating of the magnetic metallic nanowires is the frequently used solution [1-11]. Moreover, it has been reported previously that a proper incorporation of dielectric loss material and magnetic loss material has synergistic advantages in enhancing the microwave [12, 13]. Highly ordered and well-aligned TiO_2 nanotubes are used as template for the preparation of magnetic metallic nanowires and nanotubes due to high resistance and high specific surface area in some early works [9-11]. To prepare the TiO_2 nanotube arrays towards the template-based synthesis, electrochemical anodization is one of the widely used methods [14]. The presence of barrier layer at the bottom of TiO_2 nanotubes leads to equal conductivity of bottom and inner wall of such nanotubes, but electrodeposition of metal by bottom-to-top growth process needs conductivity difference between bottom and inner wall of the nanotubes [15]. As an alternative approach to the electrochemical anodization, a promising technique for the preparation of TiO_2 nanotube arrays is to utilize porous template such as AAO membrane template [16-18]. The absence of barrier layer is favorable to the deposition of magnetic metals [19, 20].

With the controllable preparation method of metal/TiO_2 nanocomposites being established, it is increasingly promising to implement these types of material towards microwave absorption. The effects of the microstructure and the content of the metallic component on the magnetic and microwave-absorption properties have been investigated in some early papers [1, 21-22]. However, very few investigations have revealed the influence of annealing on the magnetic and microwave-absorption properties of metal/TiO_2 nanocomposites. Annealing can influence the microstructure of metal/TiO_2 nanocomposites, and the microstructure can affect the magnetic and microwave-absorption properties of the nanocomposites. Therefore, it is meaningful to explore the influences of annealing on the microstructure, the magnetism and especially on the microwave-absorption properties of the nanocomposites, which is significant for the potential application of the nanocomposites in magnetic recording and microwave absorption under the condition of high temperature.

Herein, we fabricated a set of uniform, high-filling Fe/TiO_2 core/shell nanowires using the AAO membranes with different pore size. Morphology, elemental composition, and microstructure of the Fe/TiO_2 core/shell nanowires were then characterized, which manifests the successful formation of the nanocomposites. The influences of annealing on the microstructure, magnetism and microwave-absorption properties of the nanocomposites were investigated and discussed in detail for the first time. We discovered that the partial crystallization of amorphous TiO_2, polycrystalline structure of TiO_2, and the growth of Fe nanograins originating from annealing had critical influence on the magnetic and microwave-absorption properties of Fe/TiO_2 core/shell nanocomposites.

2. Materials and Methods

2.1. Preparation of Fe/TiO_2 core/shell nanocomposites

An electrochemical workstation (Princeton, ParStat4000) was used for the controllable preparation of TiO_2 and the deposition of Fe. Preparation of TiO_2